# Sensitivity and Relevance of Current Test Methods

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**Sport Surfaces Research Group**

(Thanks to Kathryn Severn and Dr Colin Young)

# Talk Outline

Brief Introduction - Why Test?

Measuring Performance and Safety

Tests methods and some data

Summary of Findings and Research Needs?

- provoke some thought/discussion!

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# Introduction – Why Test?

1. Users – Safety, comfort, skill level…IGB guidance, biomechanical validity, injury studies
2. Construction Quality Assurance: product compliance, build quality, client confidence…
3. Monitoring and Evaluation… Initial Conditions, long-term behaviour, maintenance effects, (simple tests?)
4. Research (& development)…In-house for product development, develop understanding and ‘science’ that can be applied

# Testing – Some Issues

Currently the IGB ‘performance’ guidance used to provide some assurance for the ‘user’, and for CQA, Monitoring (some) and R&D to varying levels.

This is appropriate to a degree, but does raise the question of the relevance of the tests and their sensitivity to the important parameters that are being measured…

Important question – what do the (current) tests measure?

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# User Requirements - Optimise Performance and Safety


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# Measuring Performance and Safety

USER aspects:

- Player movements (starting/stopping, running, turning, jumping, landing etc..)
- Player individuality, mass, training & conditioning, motor skills (fatigue), specific footwear..

Forces, velocity, acceleration, direction, area and rates of loading..complex

# Measuring Performance and Safety

Surface interaction aspects:

- Hardness, compliance, energy absorption/return
- Friction/traction – linear/rotational
- Materials – stiffness, friction/strength, compressibility, visco-elasticity/non-linearity, fibre/fill interaction, composite layer interaction effects

# Measuring Performance and Safety

Test equipment aspects:

- Reliability of the measurement (Repeatability, reproducibility)
- Precision/Accuracy
- Validity – both precise and accurate

# Measuring Performance and Safety

Indirect measurements are currently used……

- Validity, accurate relative to the 'real situation'?
- Sensitivity, precise to a level that is 'significant' to the user?
- Player perception vs Data ? Useful for 'ranking' pitches and their *relative* performance
- Player safety – hard to quantify 'risk' of actual harm, overuse or acute injuries, limits based on experience rather than *mechanisms*…

# Measuring Performance and Safety

- Some observations on Performance/Safety, two key areas

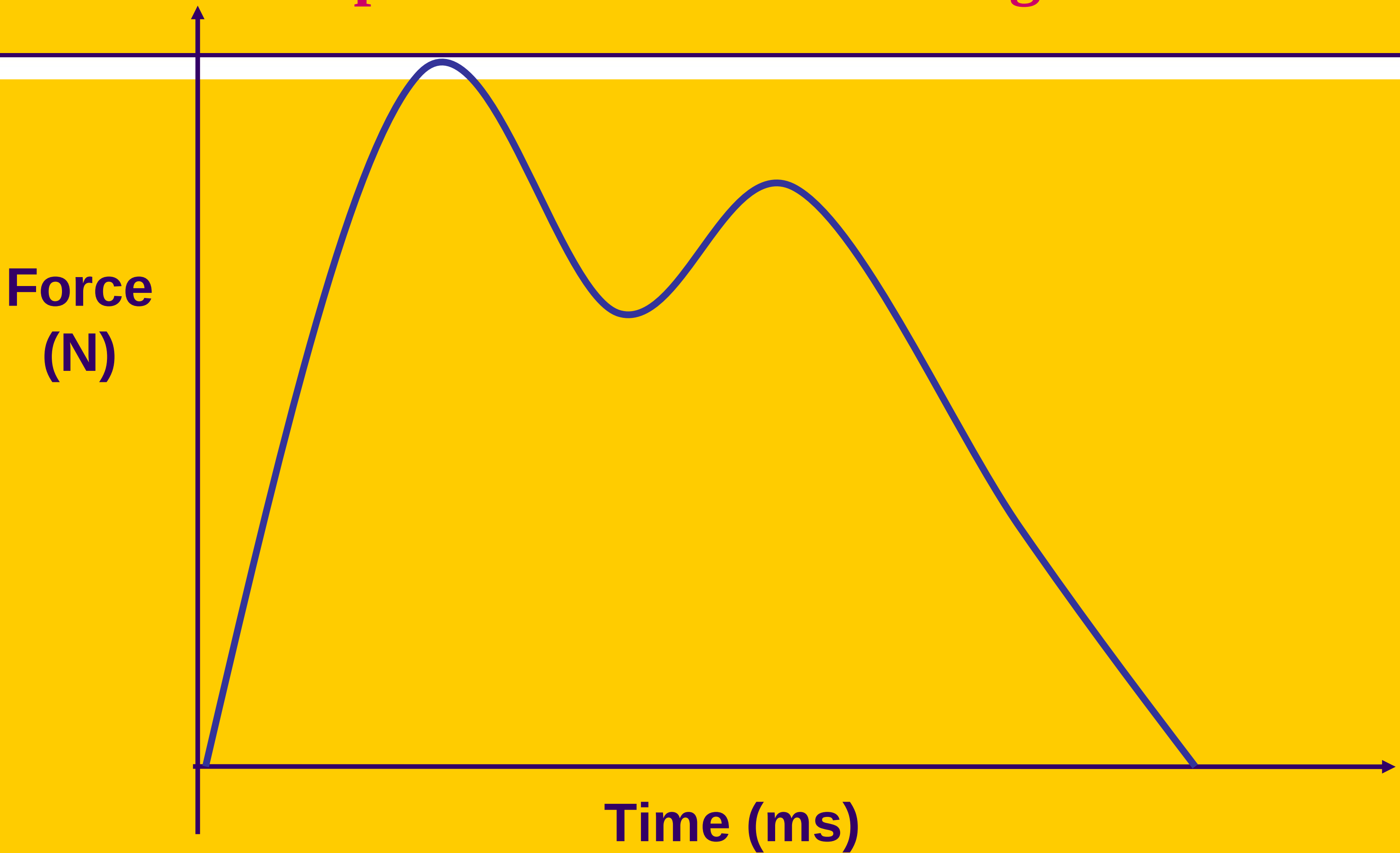
- ‘Impact’ and ‘Friction/Traction’

# Factors Affecting Impact Testing

- Factors include:
- Test force magnitude and duration (rate)
- Surface contact area
- Plane/Studded footwear - some effect
- Viscous and non-linear strain response of the materials (Carpet, fill, shockpad)
- Composite - layer interactions (zone?)

# IMPACT

## Simplified Heel-Toe Running - GRF

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# Berlin Athlete – Impact Test

Constant Energy Test
Drop height: 55cm
Drop weight: 20 kg
Test Foot: 70mm diameter

Typical Contact Pressures:
Concrete: 1700 kPa (6.5kN)
Acrylic: 1600 kPa
Synthetic Turf: 500-1000 kPa
(2-4kN)
Load pulse: ~30 milliseconds

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# SPORT REQUIREMENTS
# Football, Rugby, Hockey

| Testing | Traction | Berlin |
| --- | --- | --- |
| | (Nm) | (FRF %) |
| FA<br>FIFA | 30-50 Nm<br>1 star: 25-50 Nm<br>2 star: 30 – 45 Nm | ≥ 55 % (studded foot)<br>1 star: 55 – 70 %<br>2 star: 60 – 70 % |
| IRB | 30 – 50 Nm | 60 – 75 % |
| FIH | None | 40-65% |

# Generic Surface Types

**Unfilled (Water Based)**

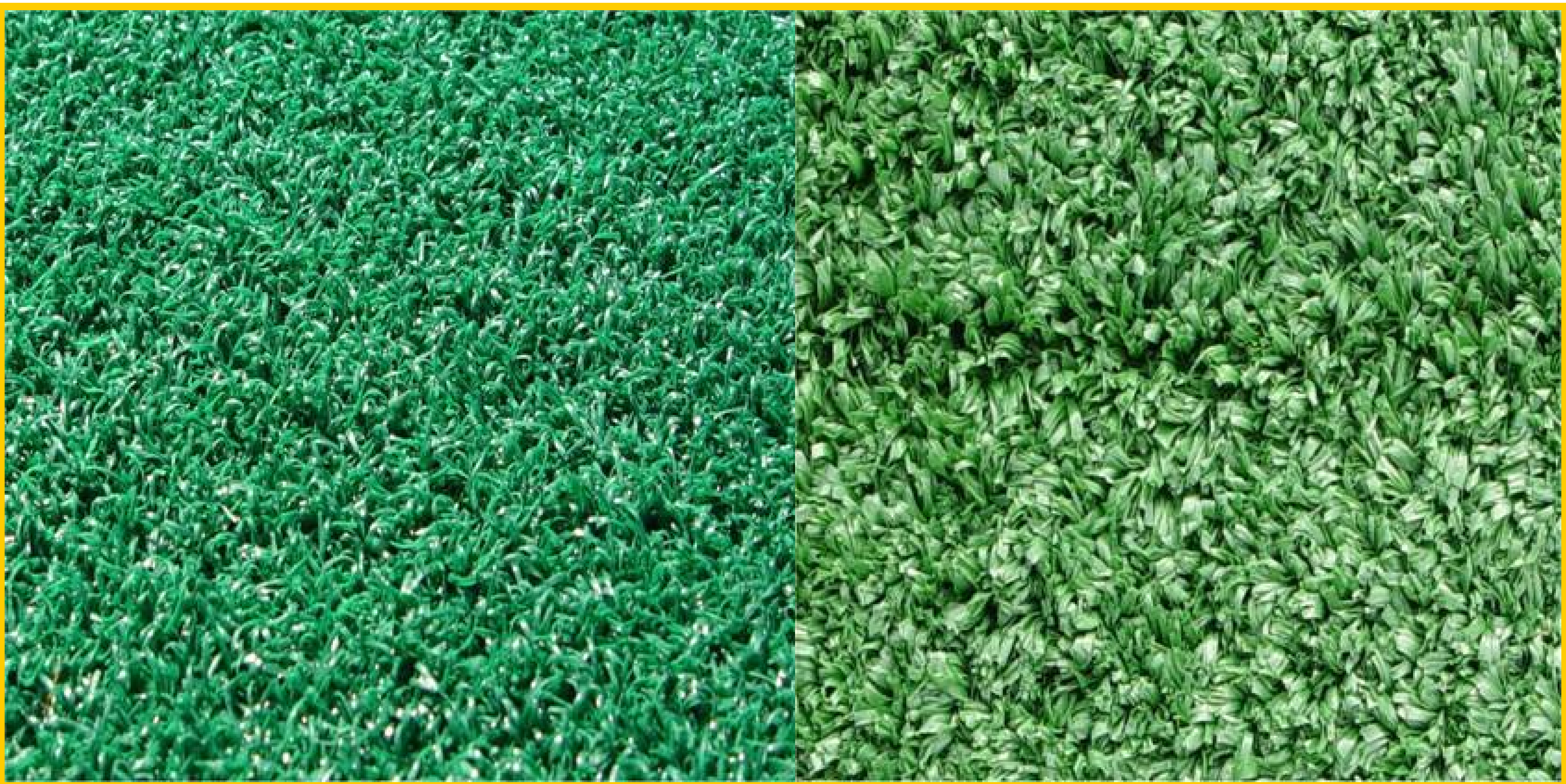
**Filled - Sand filled (dressed)**

**- Rubber (sand mix)**

**Industry developing 'low' friction unfilled surfaces….**

**System Components? Many available – 100s of bespoke designs…**

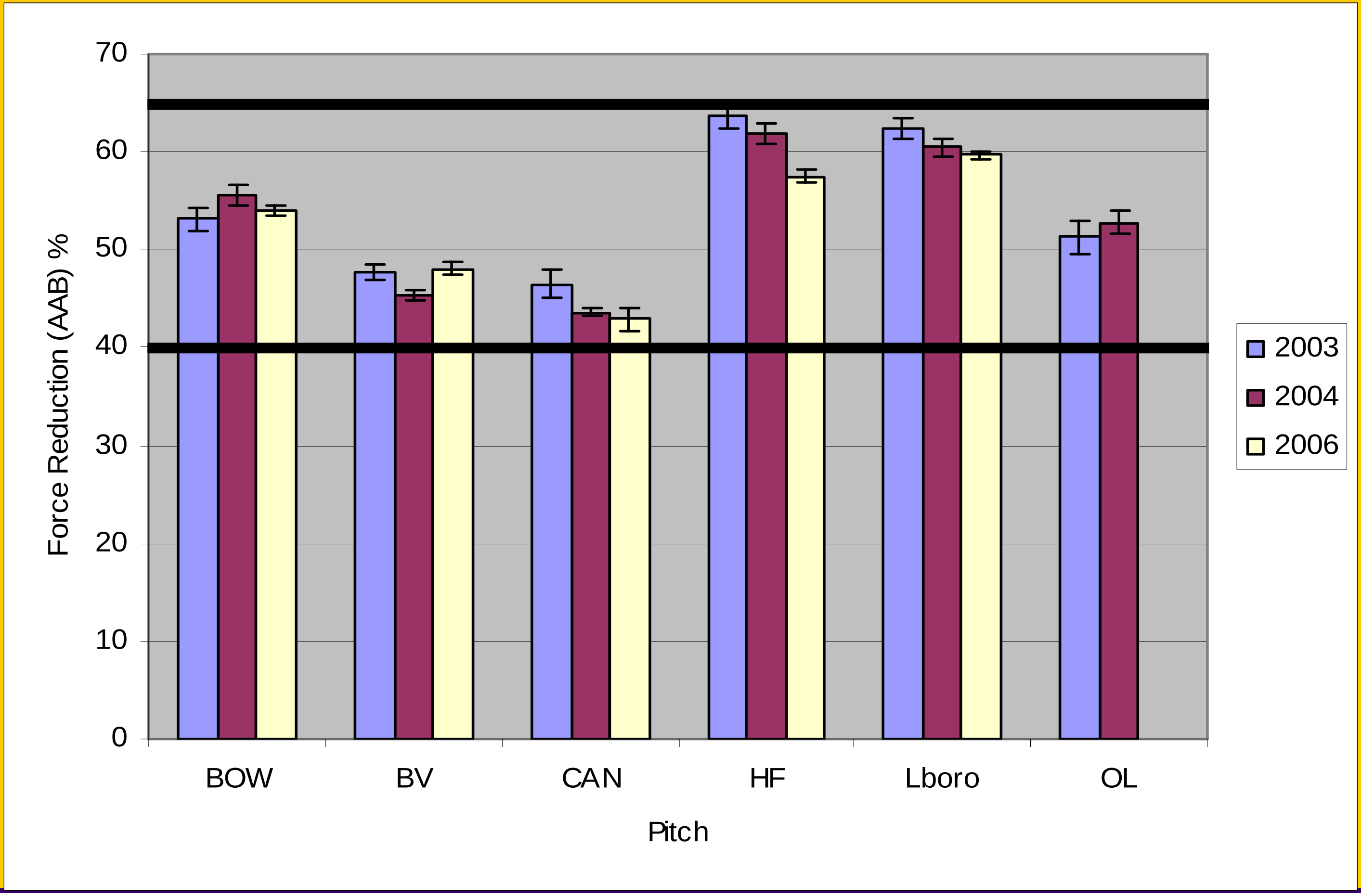
# Unfilled



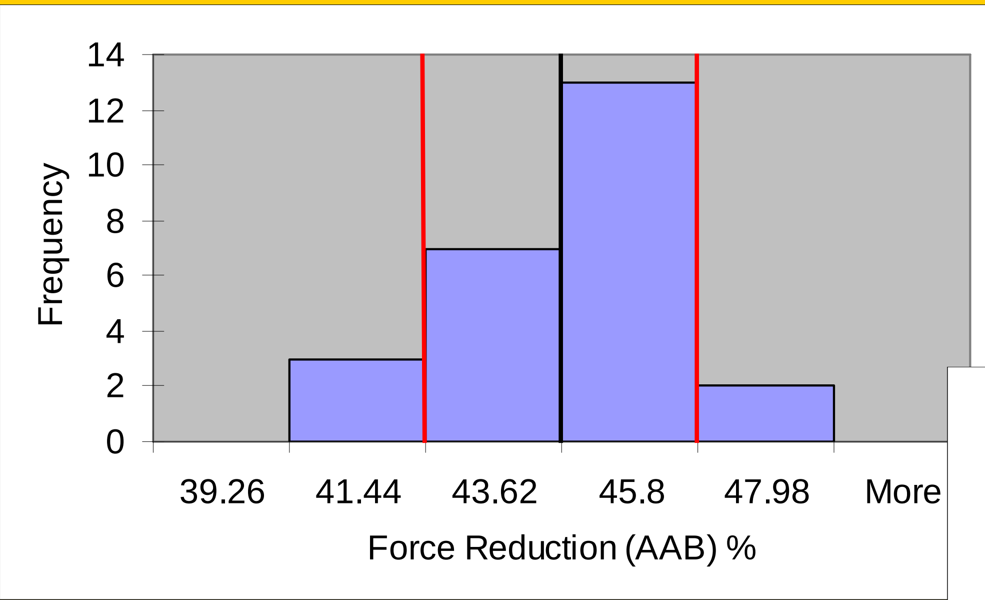
# Impact Data

- Use of Impact Devices for Monitoring and Evaluation (Berlin and Clegg)
- Use of Impact Devices for Research and Development (sports hall floors)

# Data - IMPACT
# Unfilled Hockey Pitches

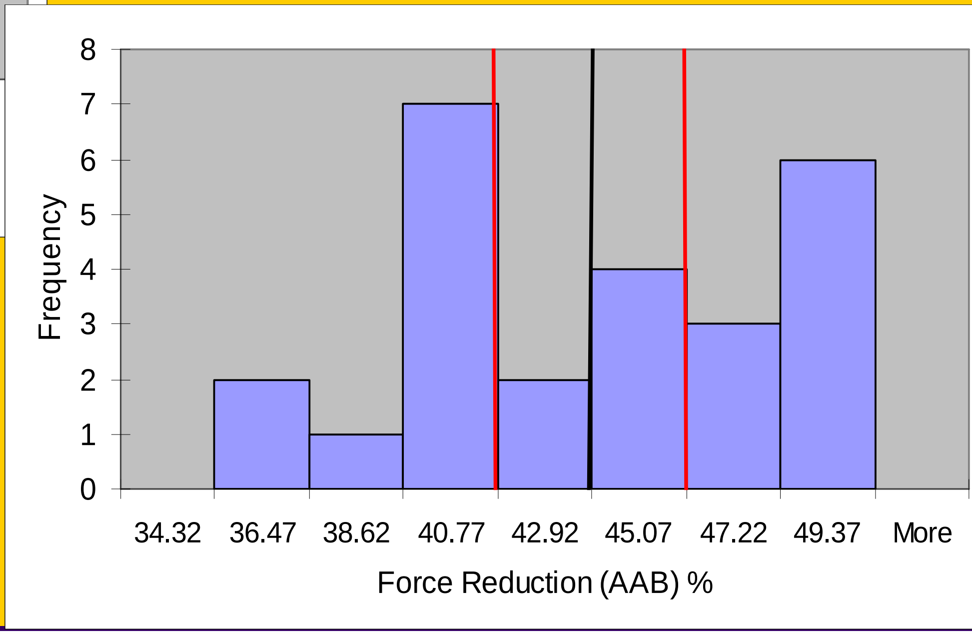


# Data – SPATIAL changes
# Unfilled Hockey Pitch




2004

2006

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# Clegg Hammer – Impact Test

Drop height: 45cm
Drop weight: 2.5 kg (0.5kg)
Test Foot: 50mm diameter

Typical Contact Pressures:
Synthetic Turf: 1000-2000 KPa
Load pulse: ~5-10 millisecs

Useful, simple, sensitive?

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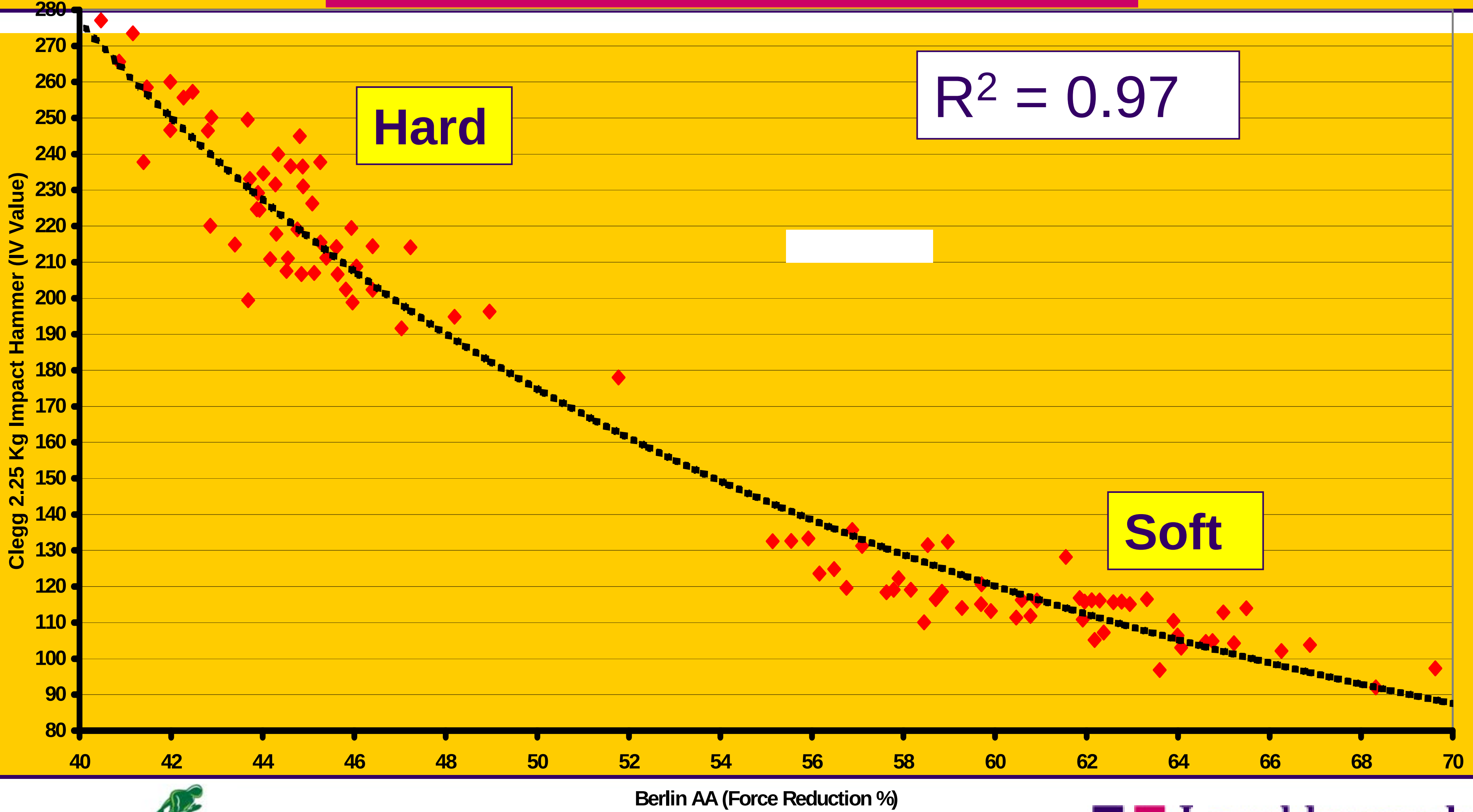
# Berlin & 2.5kg Clegg Correlation
# 6 Water Based Pitches

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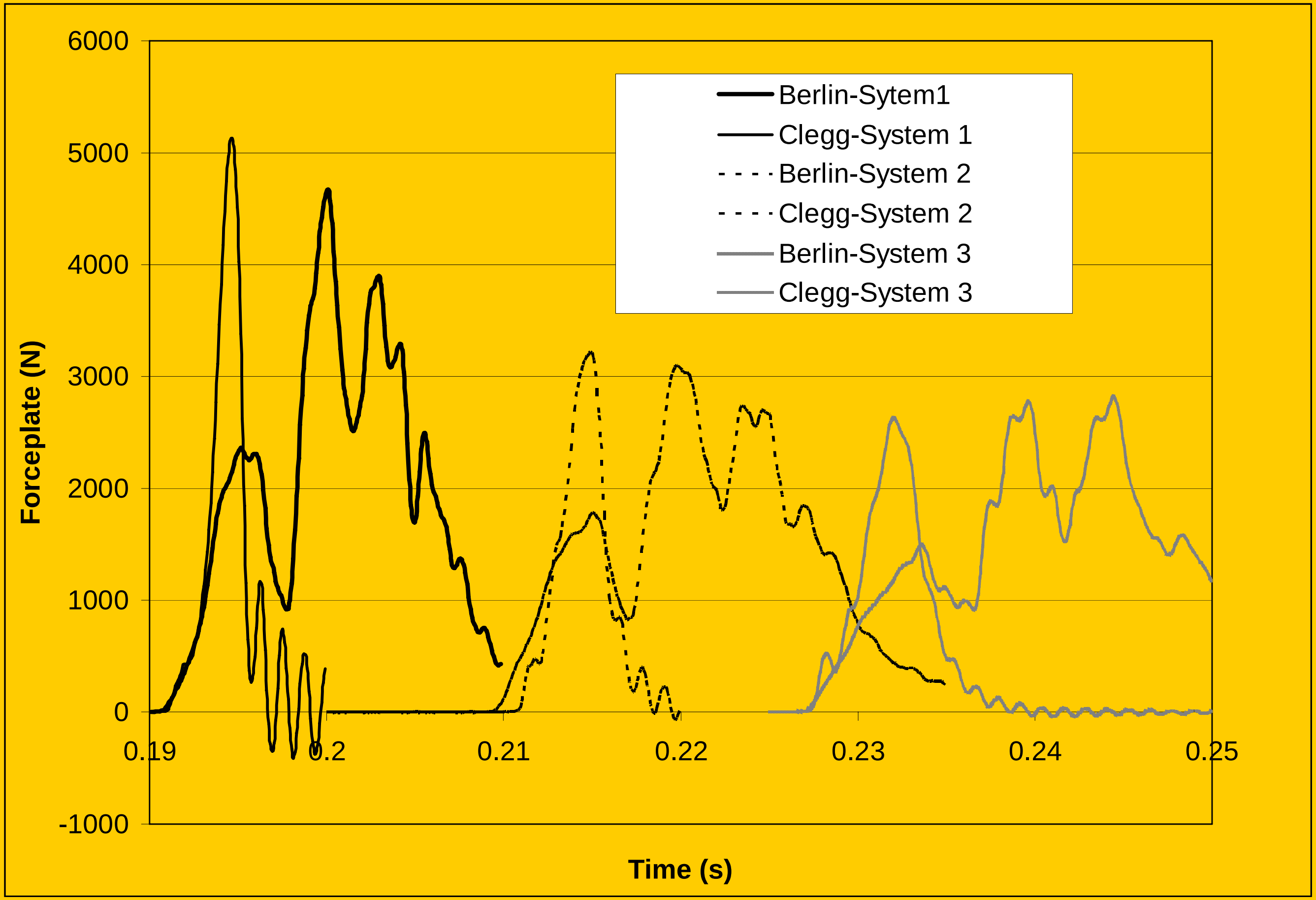
# Force Plate Data – Berlin and Clegg
# Unfilled Carpets and shockpad combinations

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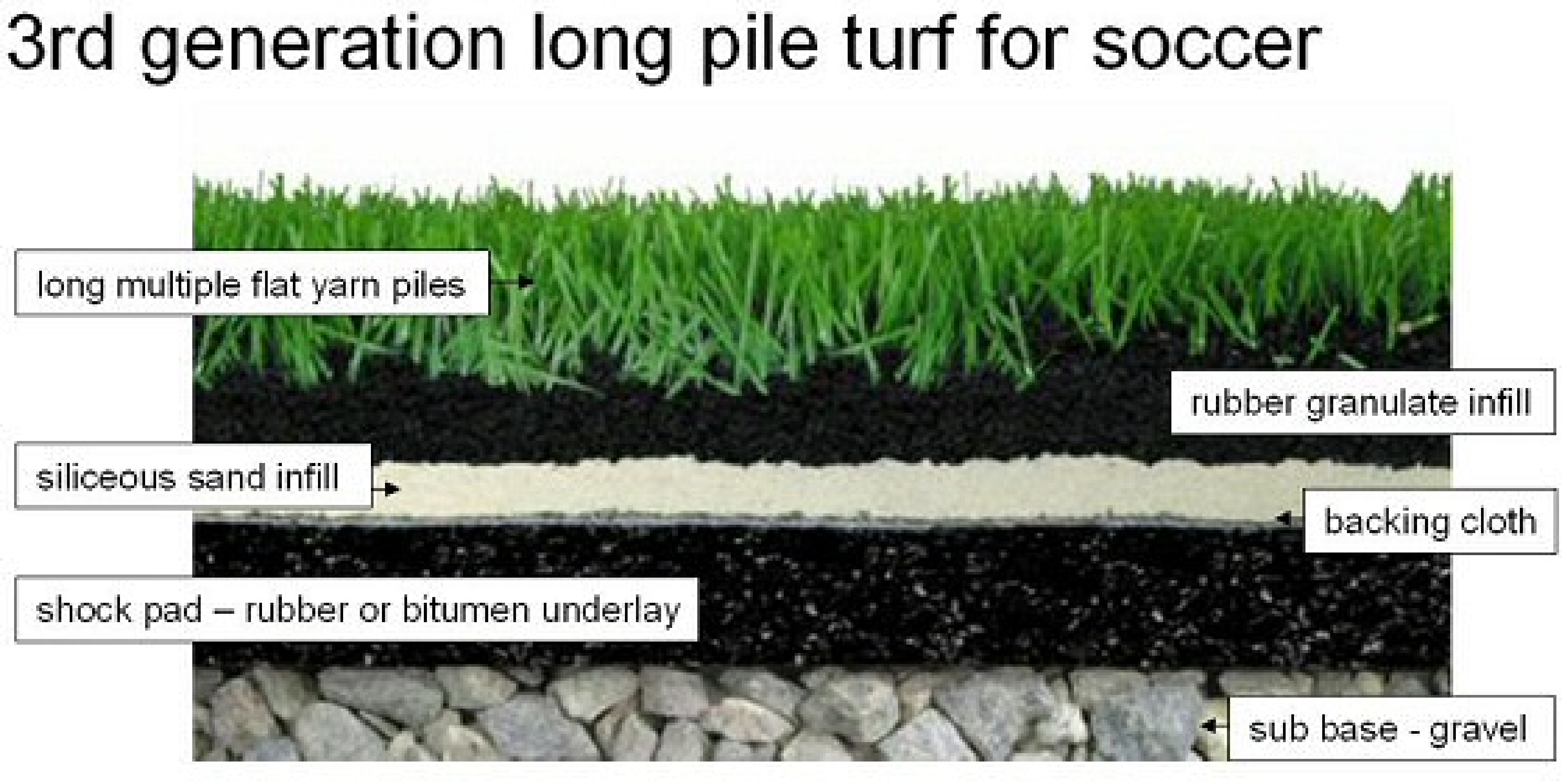
# Long-Pile – rubber filled

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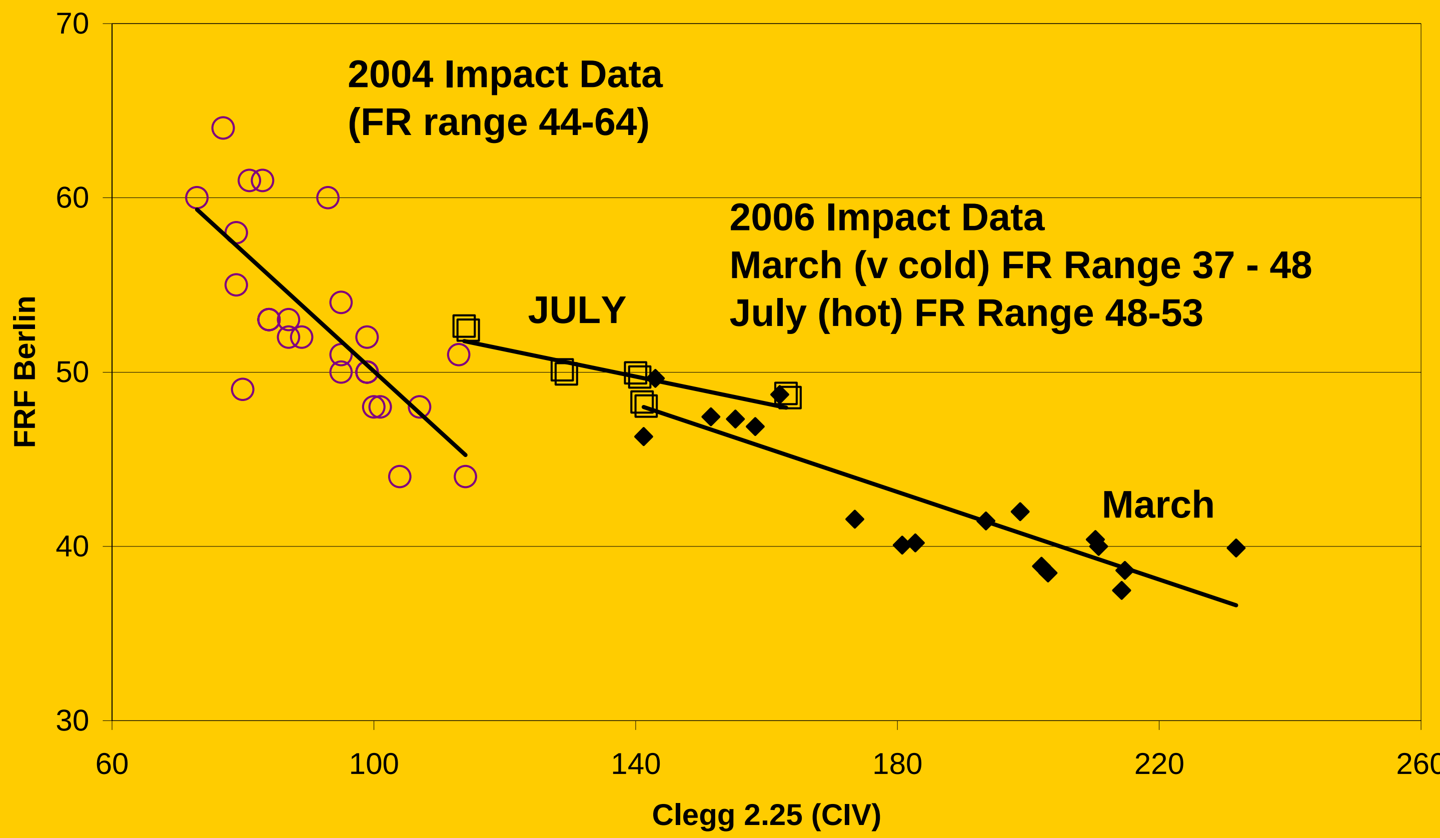
# Data
# Filled Football Pitches



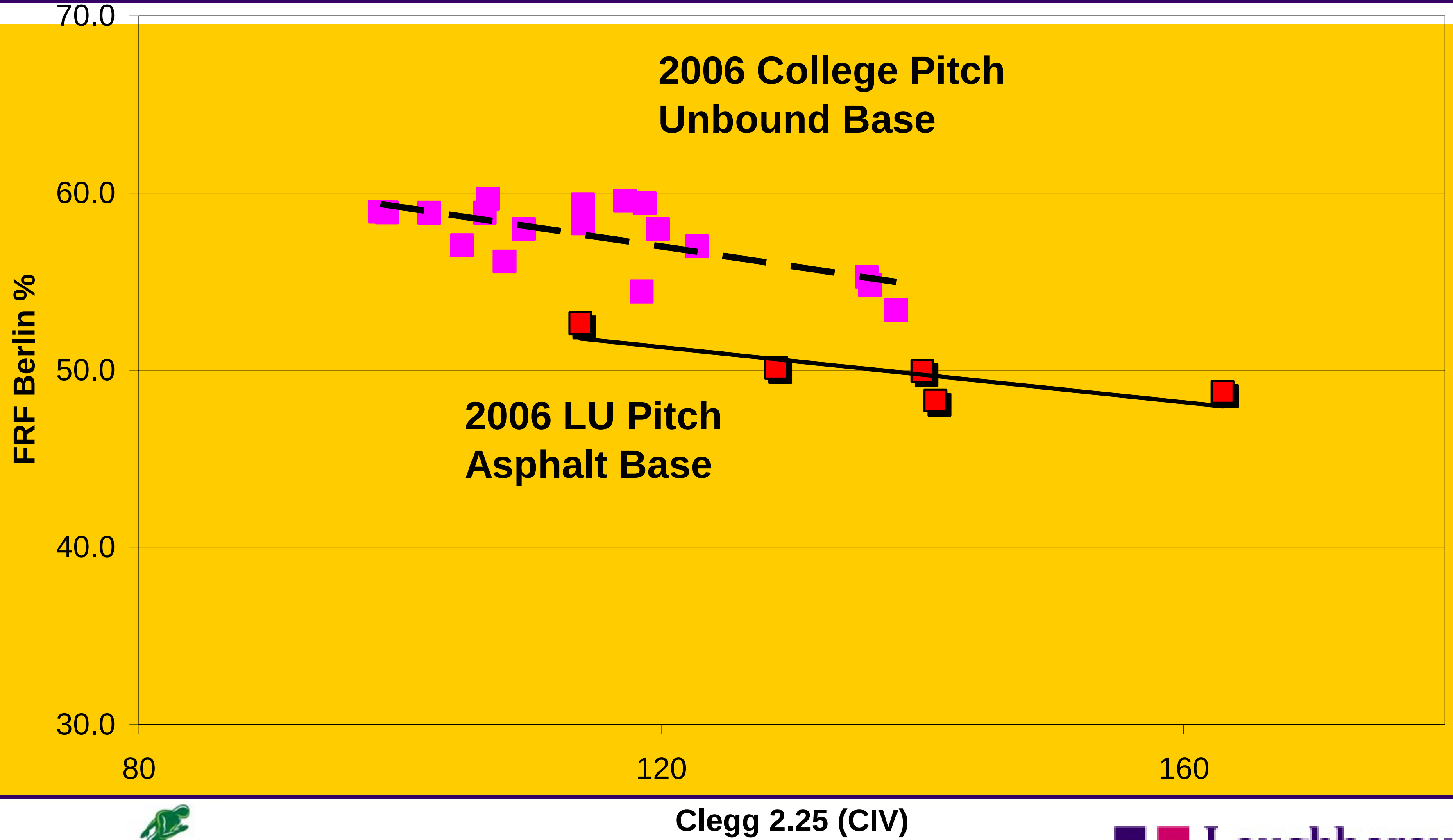
# Data-Case Study 2
# Filled Football Pitches

**"Synthetic Surface Heat Studies",** ***C. Frank Williams and Gilbert E. Pulley, Brigham Young University***

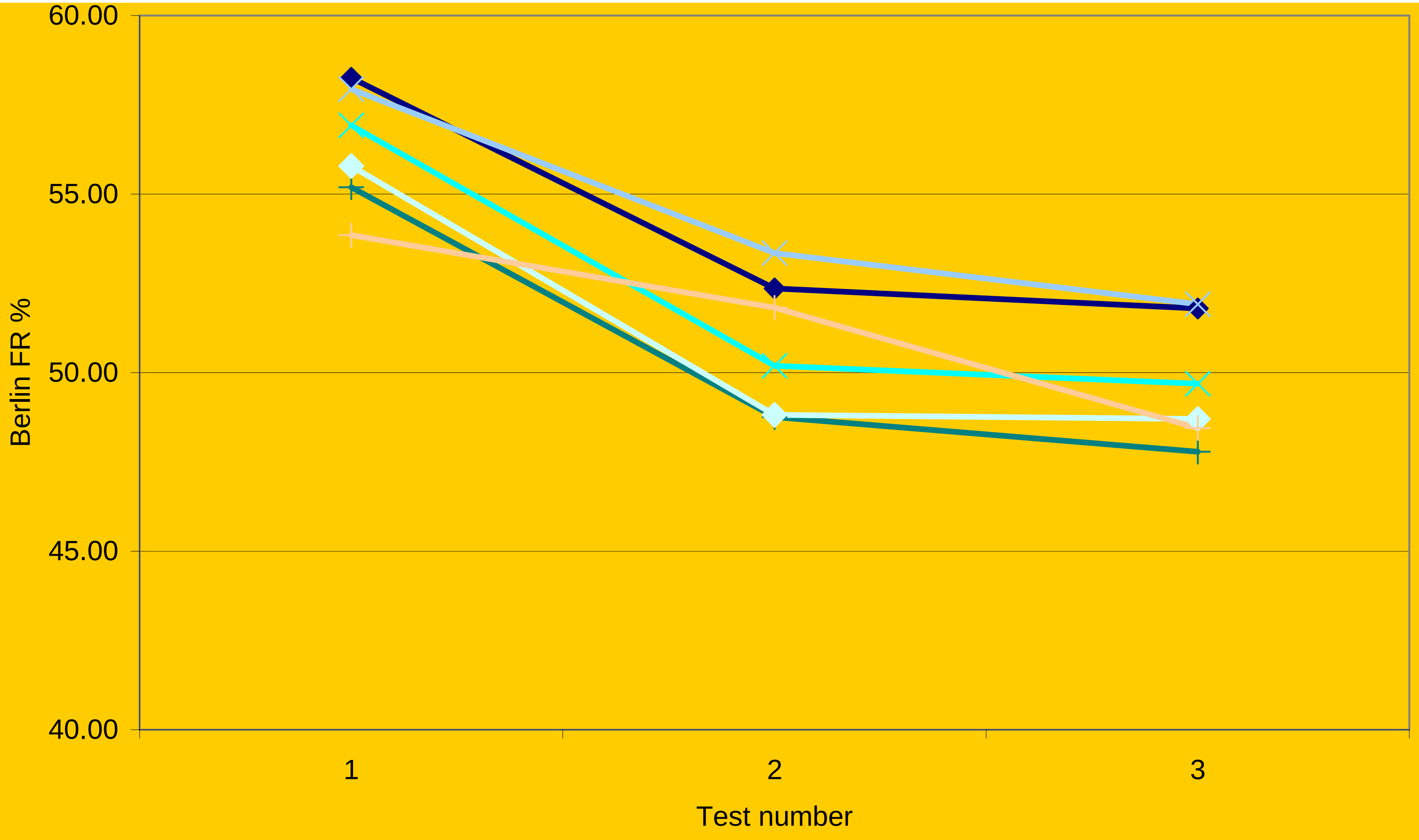
| ***Surface*** | ***Ave Surface Temp between 7AM & 7PM*** | |
|---|---|---|
| *Art' Soccer* | *117.38º F (47 ºC)* | *high 157º F (69 ºC)* |
| *Art' Football* | *117.04º F* | *high 156º F* |
| *Natural Turf* | *78.19º F (26 ºC)* | *high 88.5º F* |
| *Asphalt* | *109.62º F* | |
| *Bare Soil* | *98.23º F* | |

***Safety Officer set 120º F (49 ºC) as the maximum temperature that the surface could reach before cooling was required.***

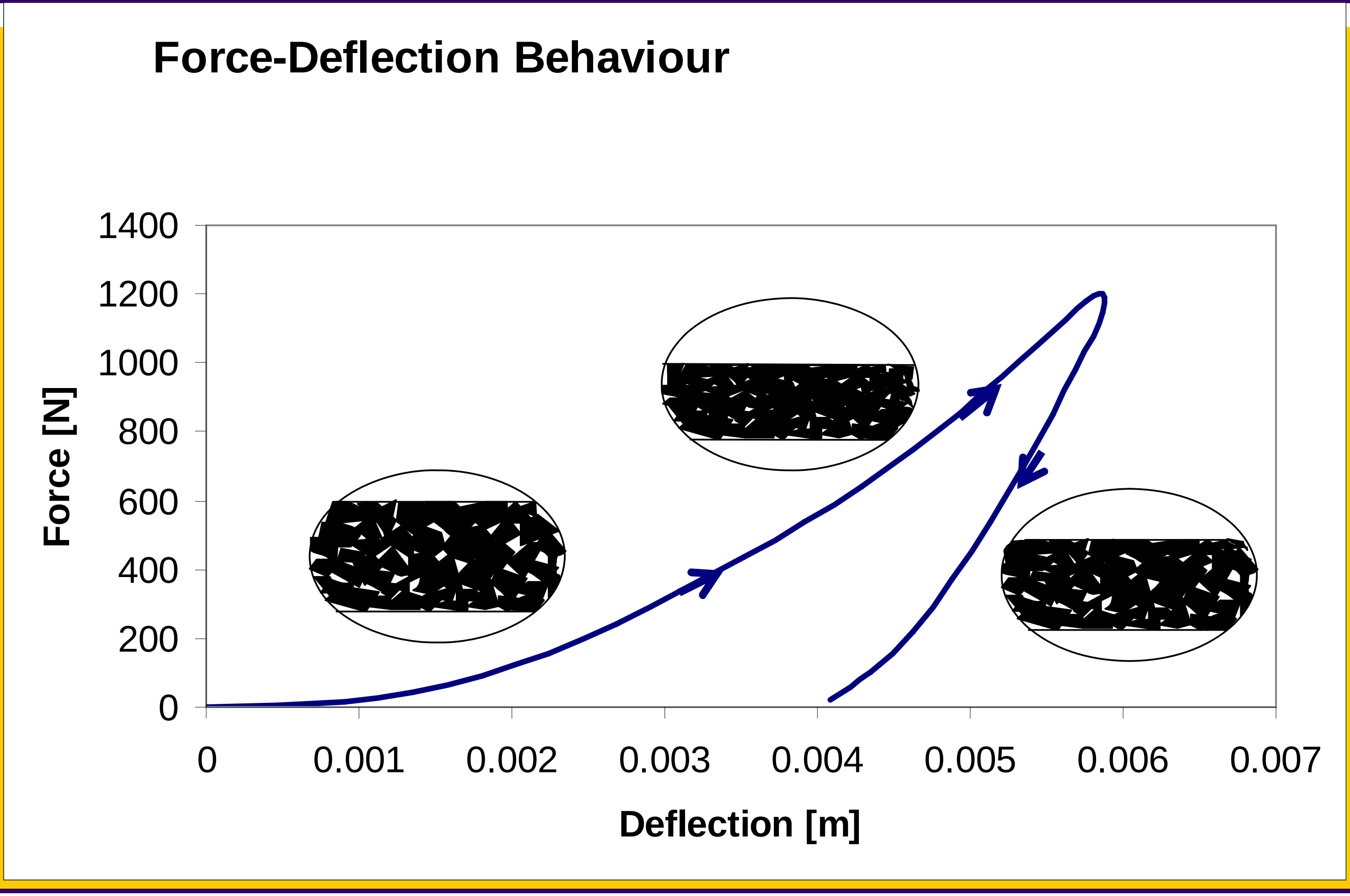
# Data
# Filled Football Pitches-Base Effect?



# Filled Football Pitch
# 3 Impacts – Berlin Athlete



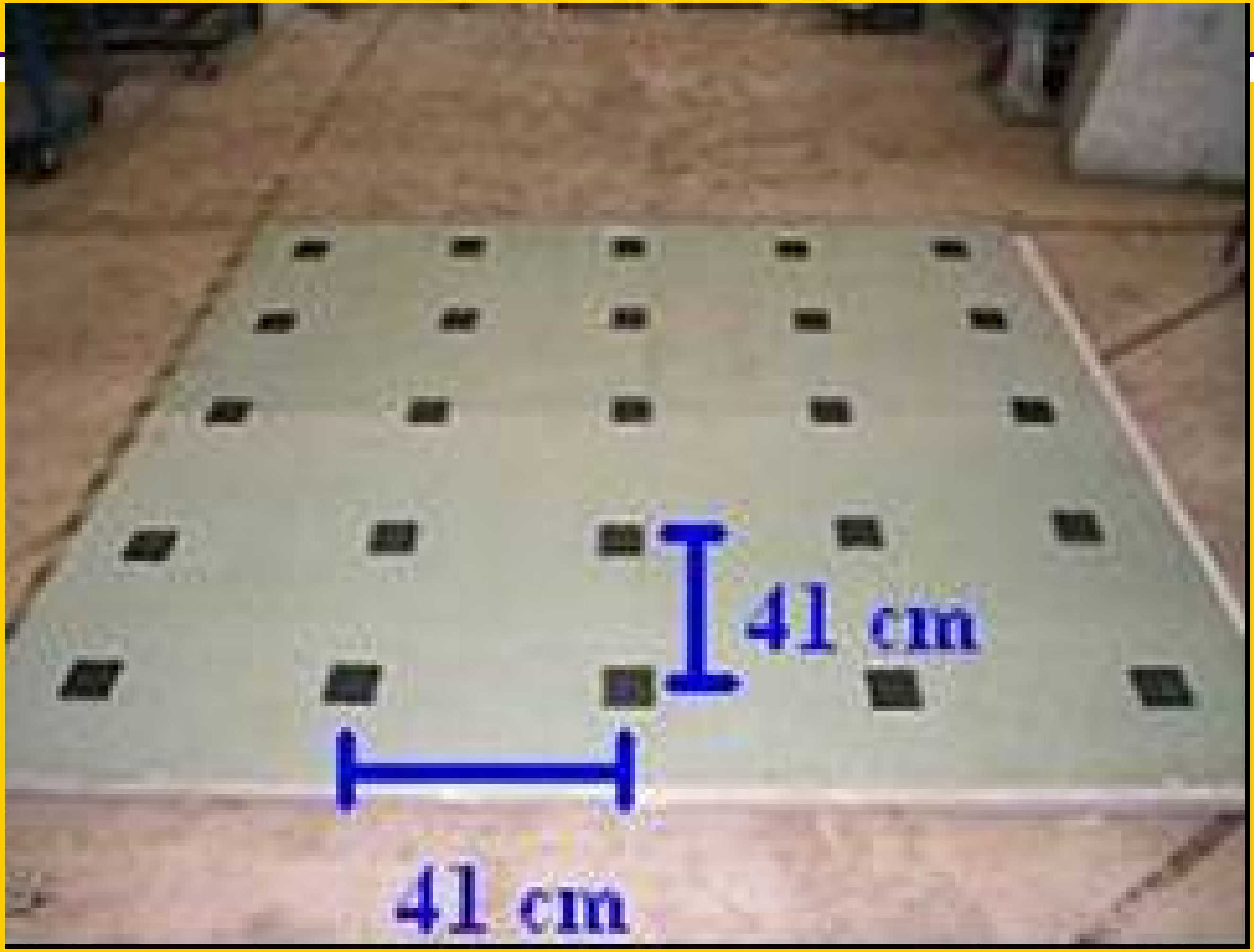
# Rubber Fill – Compression Behaviour



# ‘R&D’ Testing

Peak ‘G’ impact reaction & Berlin ‘Force Reduction’

# Floor – Pad & Board Effects



# Test Equipment: Prima Plate Test


**Controlled Force**

**Drop height: up to 85 cm**

**Drop weight: 10 - 20 Kg**

**Pulse Time: 15 – 30 ms**

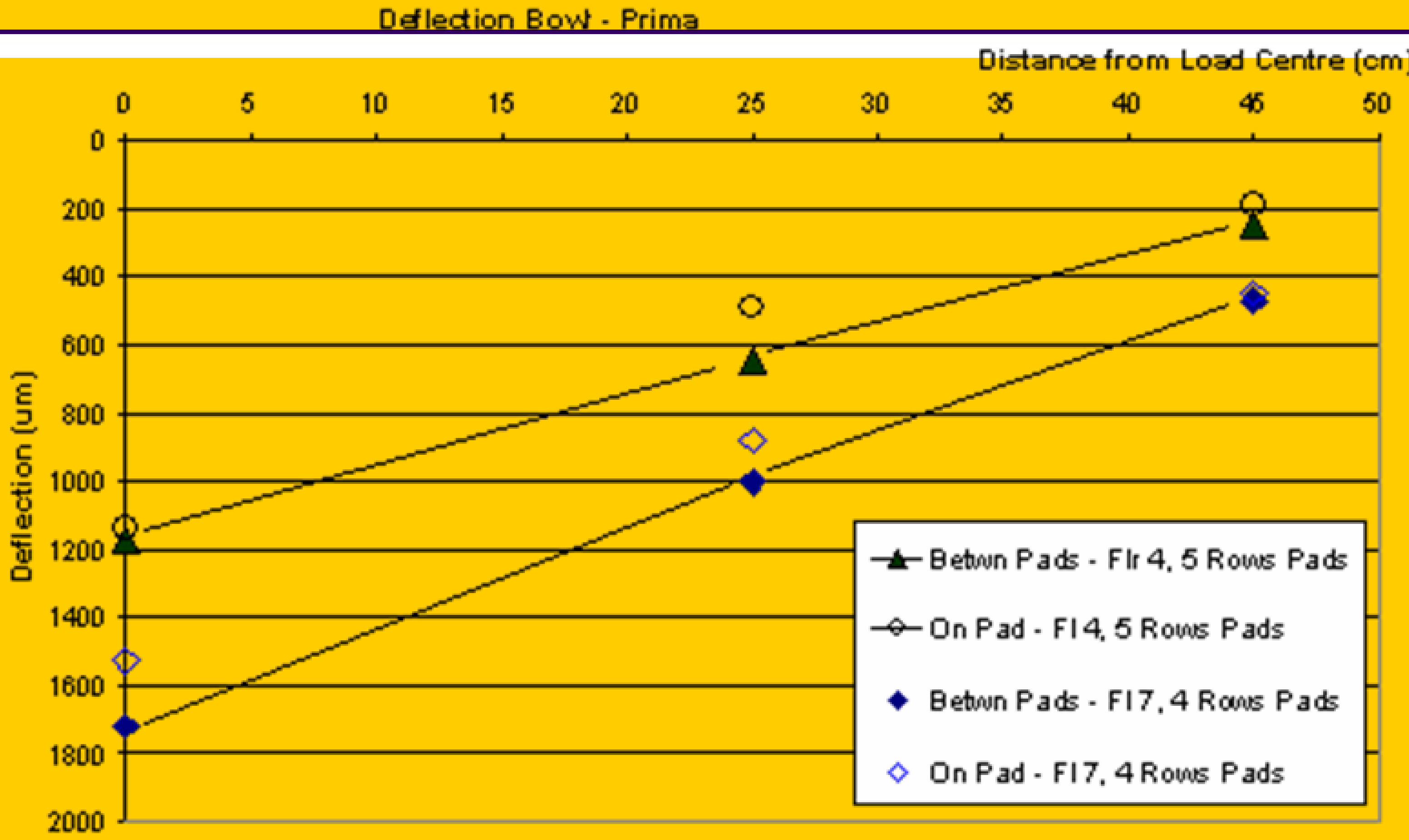
**Plate Size: 100, 200 or 300 mm**

**Load Range: 0 – 15 kN**

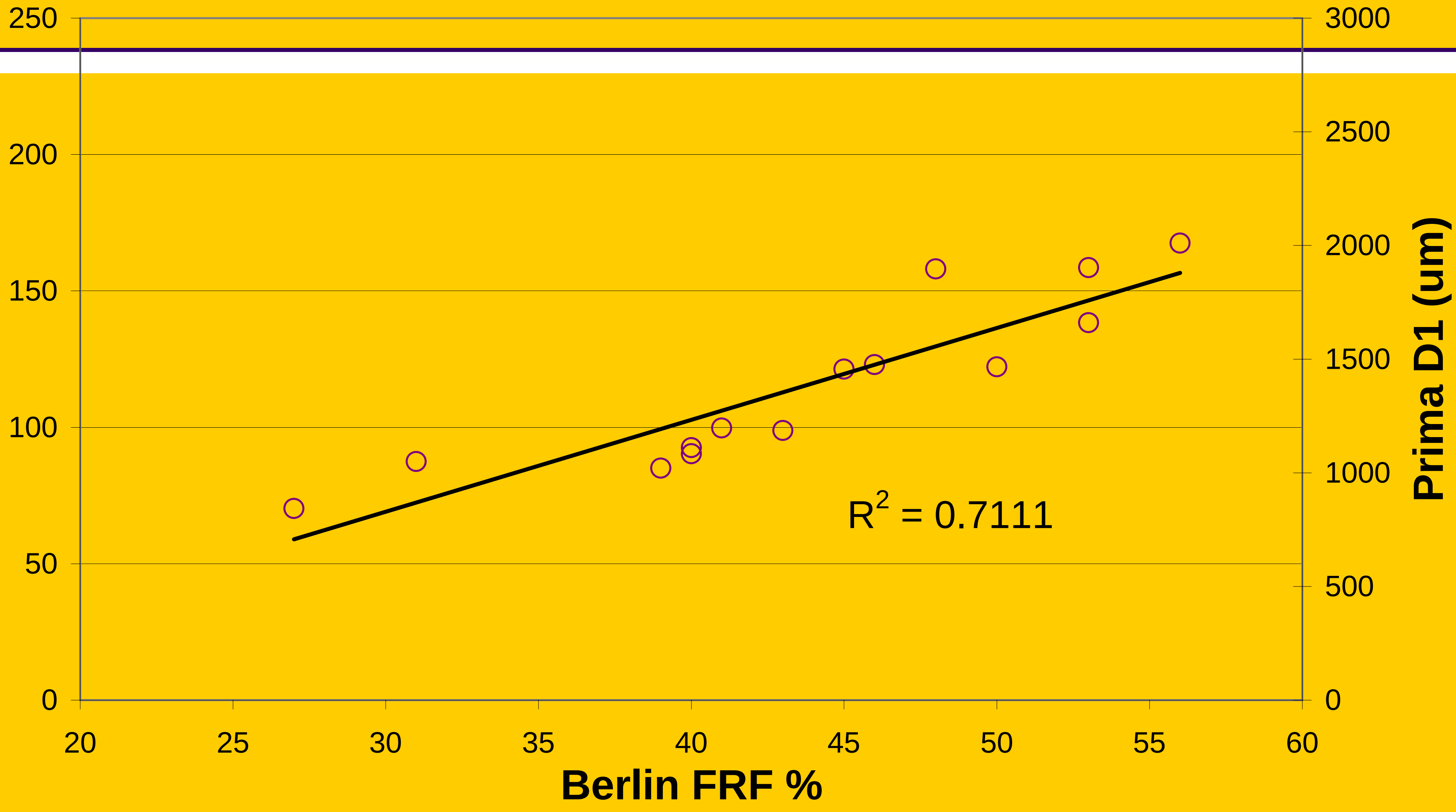
**Deflection Sensor: 0 - 2200μm**

**Sample Frequency: 4000 Hz**

# Floor – Bending Behaviour



# Berlin vs. Prima



# Factors Affecting Friction/Traction

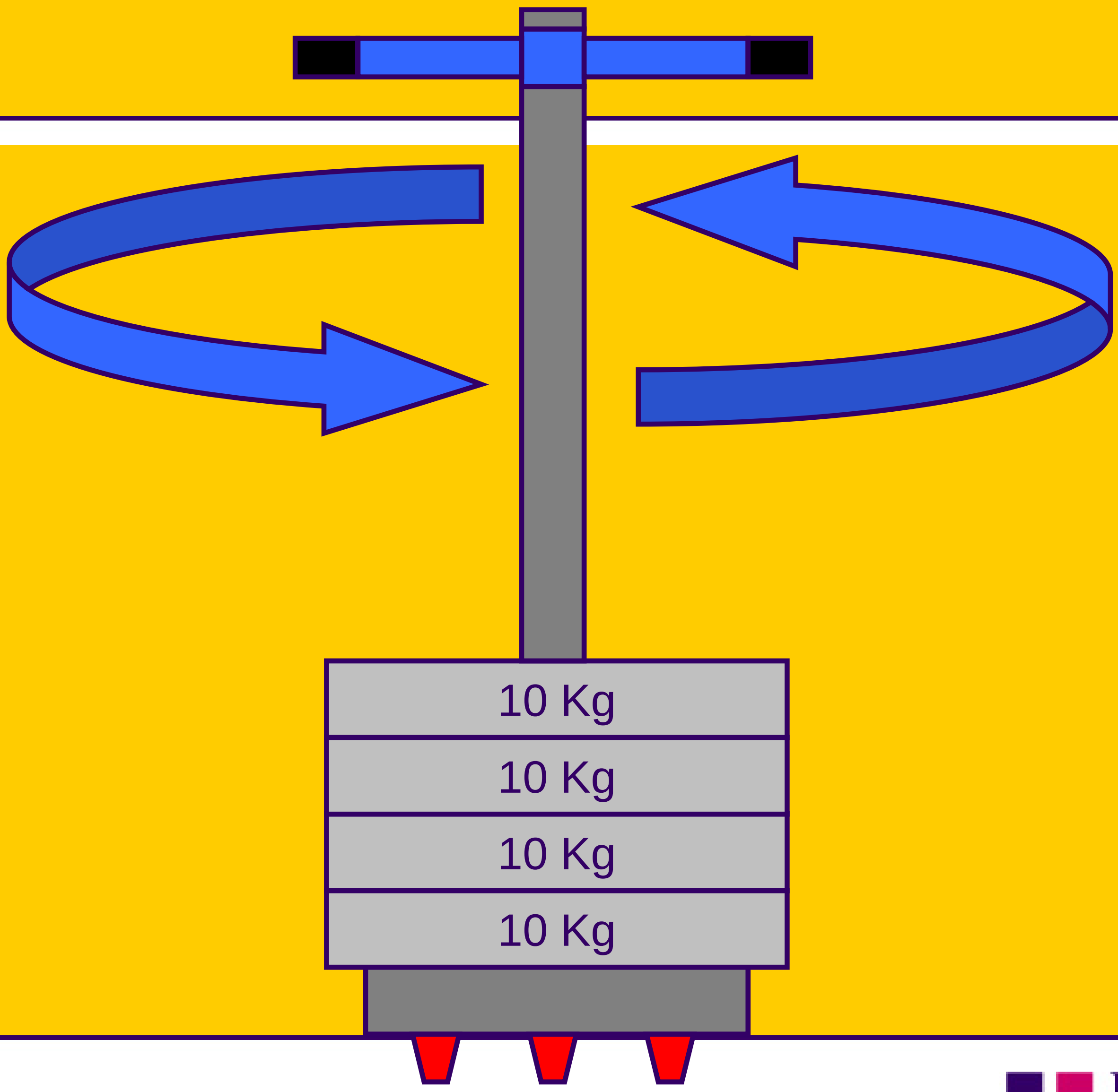
- Not Coulomb friction

- Relative velocity
- Normal force (and shear?) – significant effect..?
- Surface contact area
- Footwear – stud penetration, configuration, length, number etc.
- Material response (carpet, fill etc..) – interface(s) friction, fill shear strength, compression (dilation), fibre reinforcement/entanglement…

# Linear Friction/Traction

# Rotational Traction

# Rotational Traction

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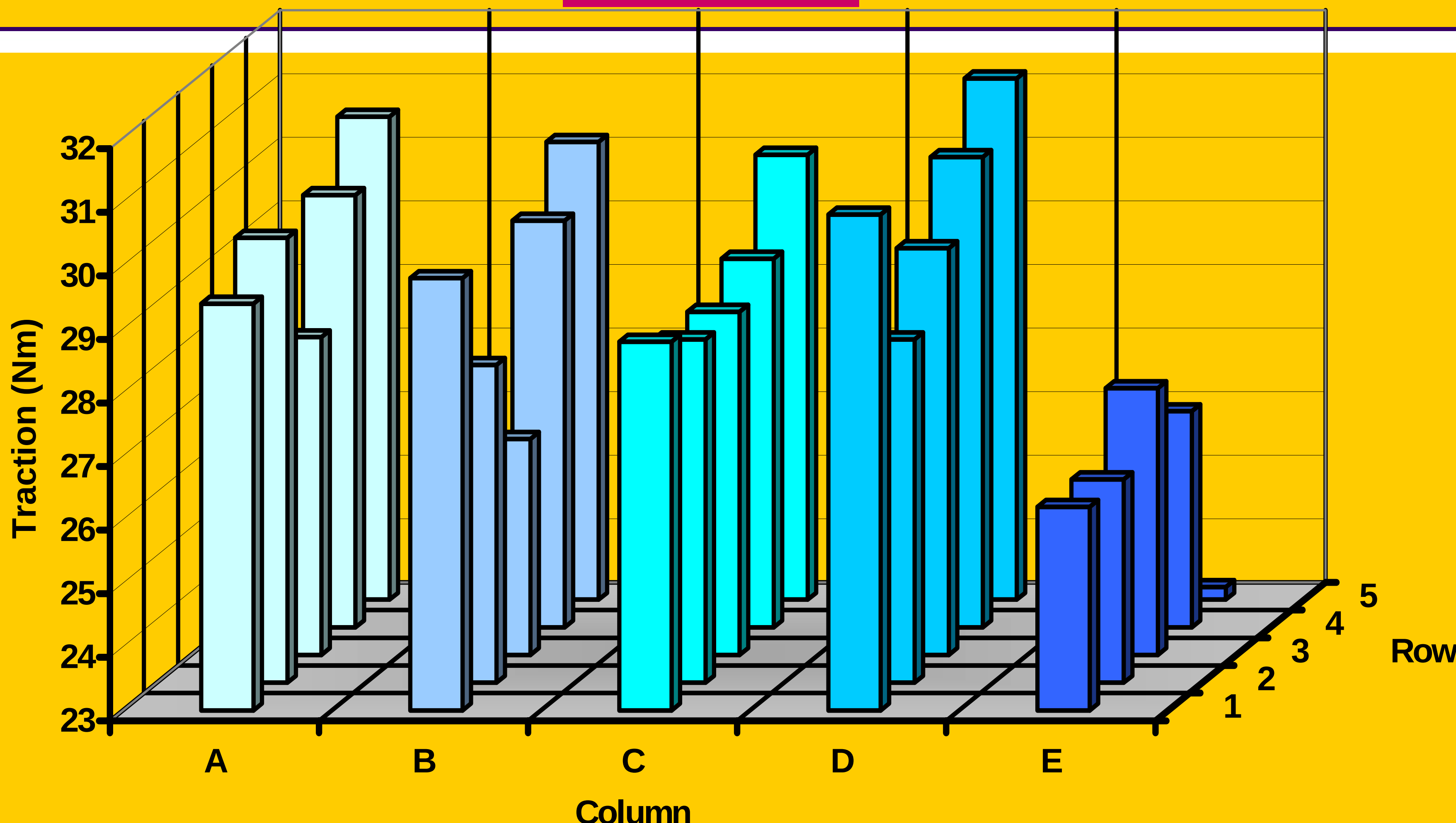
# Traction Measurement

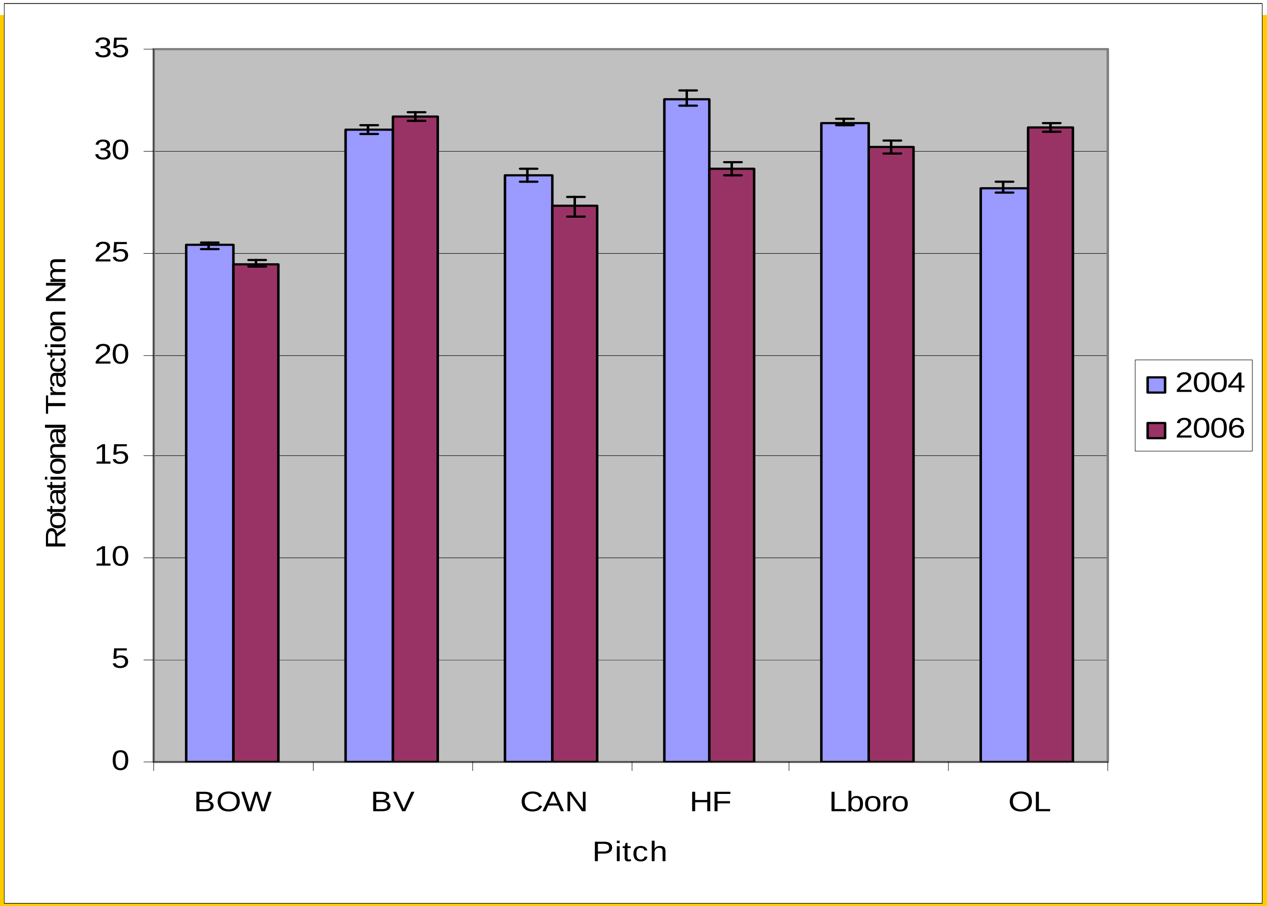
- Unfilled systems – Monitoring & Evaluation
- Filled Systems – Monitoring & Evaluation

# Rotational Traction at Pitch F (Row E)



# Rotational Traction at Pitch F (Row E - Algae)

# Data- Rotational Traction
# Unfilled Hockey Pitches

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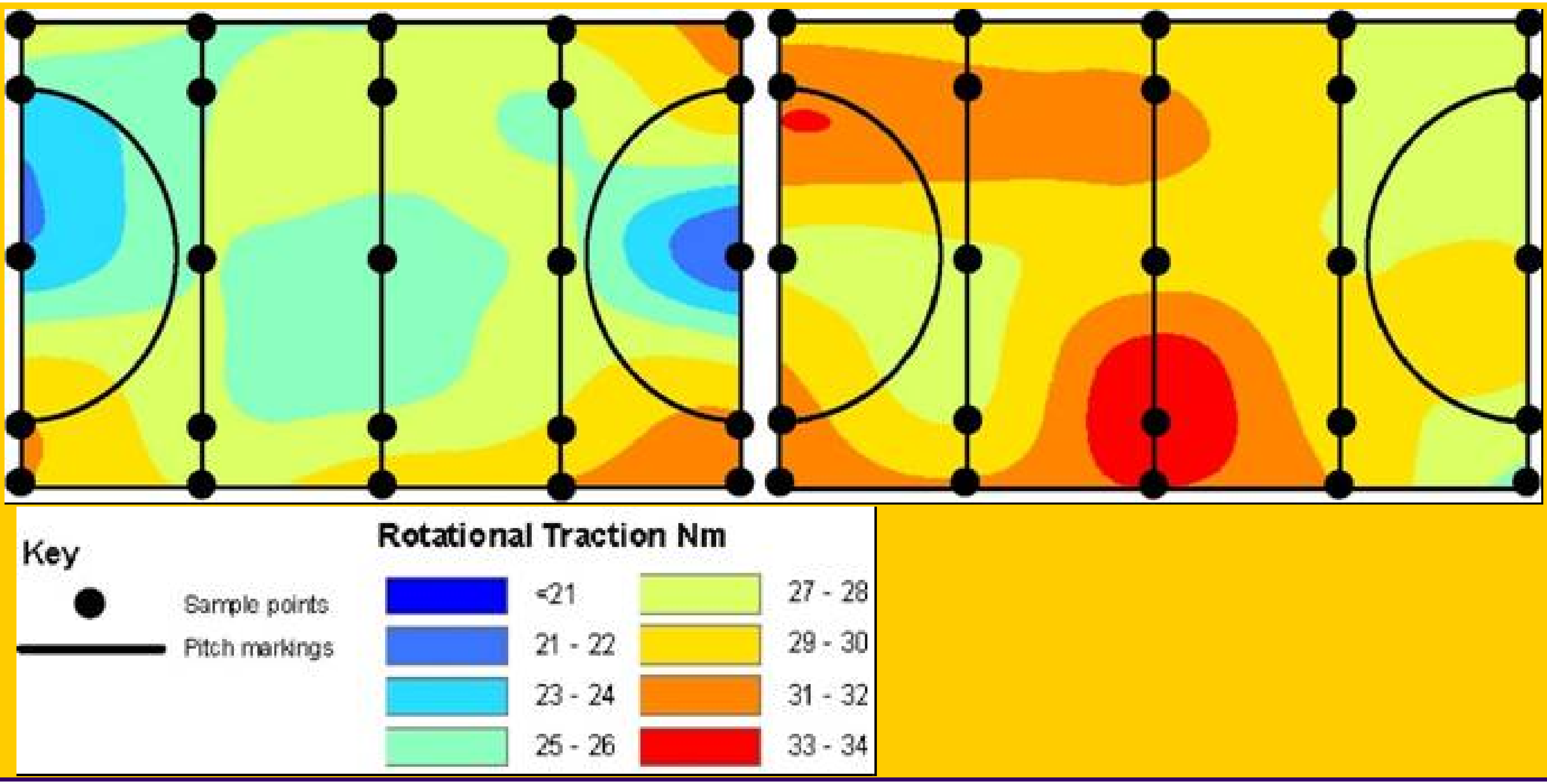
# Data - Rotational Traction
# Unfilled Hockey Pitches

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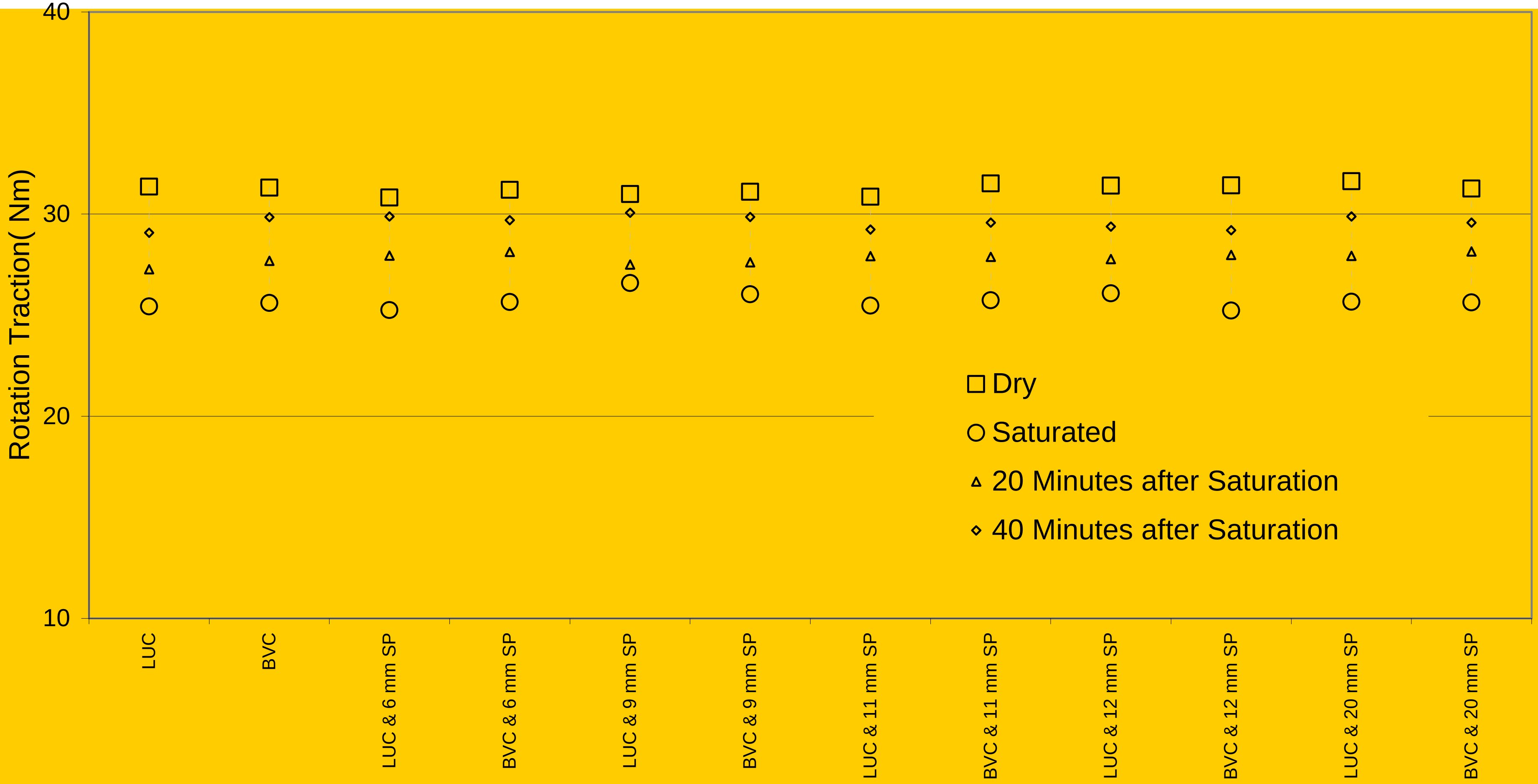
# Construction/Design Effects
# Rotational Traction vs Shockpad thickness



# Rotational Traction data
# Rubber Filled Football Pitches

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# Rotational Traction Data
# Filled Football Pitches

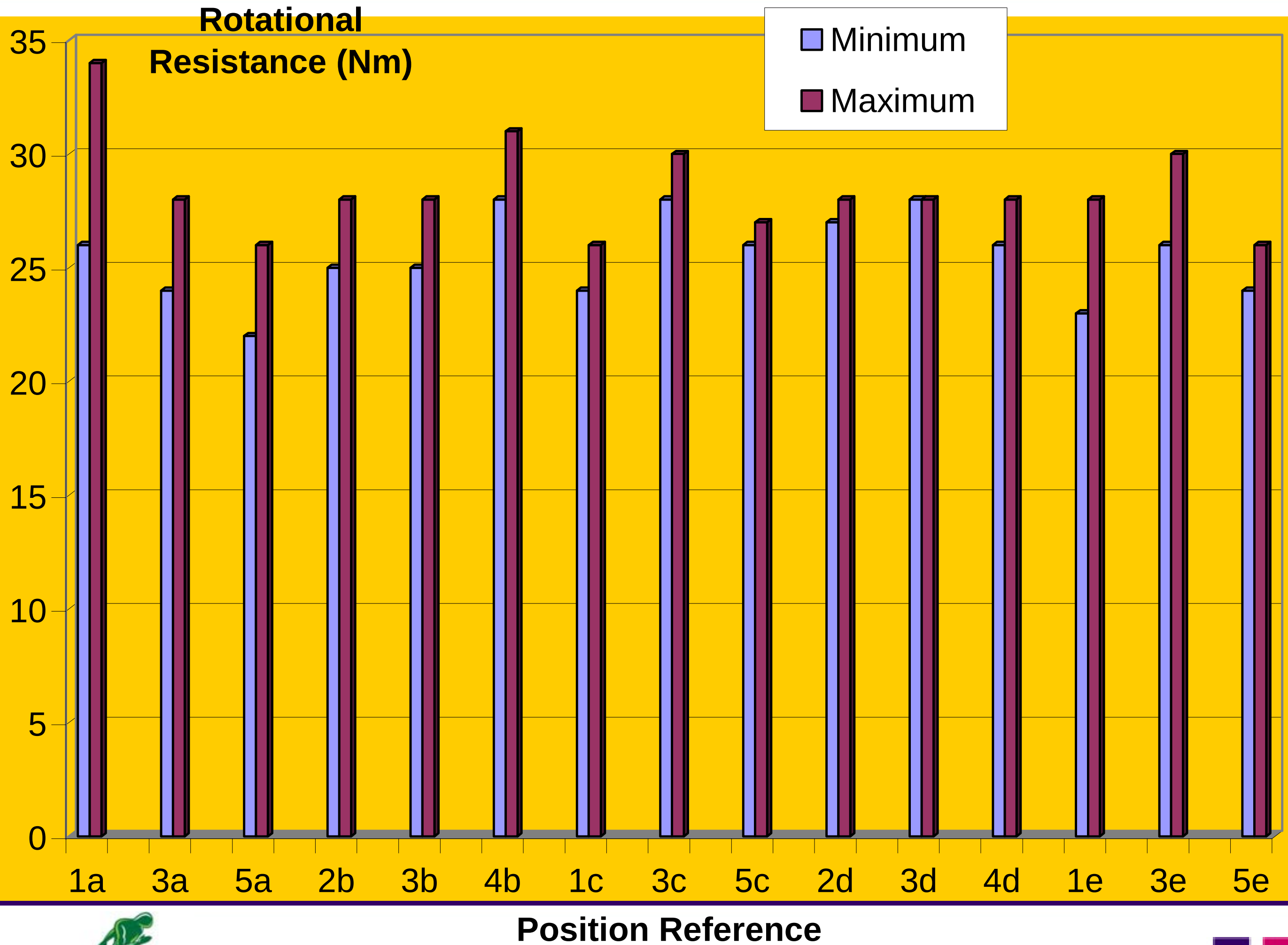
**TRACTION TEST RESULTS (Rotational Resistance)**

**LU PITCH1**

| | |
|---|---|
| 2003 – Test house | 28 (Range 27 - 29) |
| 2004 – Project | 25-28 |
| 2004 – Project | 24-32 |
| | |
| College Pitch 2 | 27-30 |

| | Fill density(kg/m³) | | Torque Nm | Berlin FRF % |
|---|---|---|---|---|
| Laboratory | 10 | a | 22-24 | 57 |
| | 16 | b | 24-26 | 62 |
| | 22 | c | 21-23 | 68 |

# Rotational Traction Data
# Filled Football Pitches




**LU Pitch 2004**

Loughborough University

# Other Data – Rotational Traction

- 45-65kg static force increased Torque from 36-49Nm, infilled SBR. (Vachon, 2005)
- IBV (2003) measured 38-47 on Infilled Artificial Turf, 38-68 on Natural turf
- Shorten (2002) – shoe <u>and</u> surface required. Rotational traction should be as *low* as possible - not linked to athletic manoeuvre
- Strathclyde Research has looked at multivariate approach…

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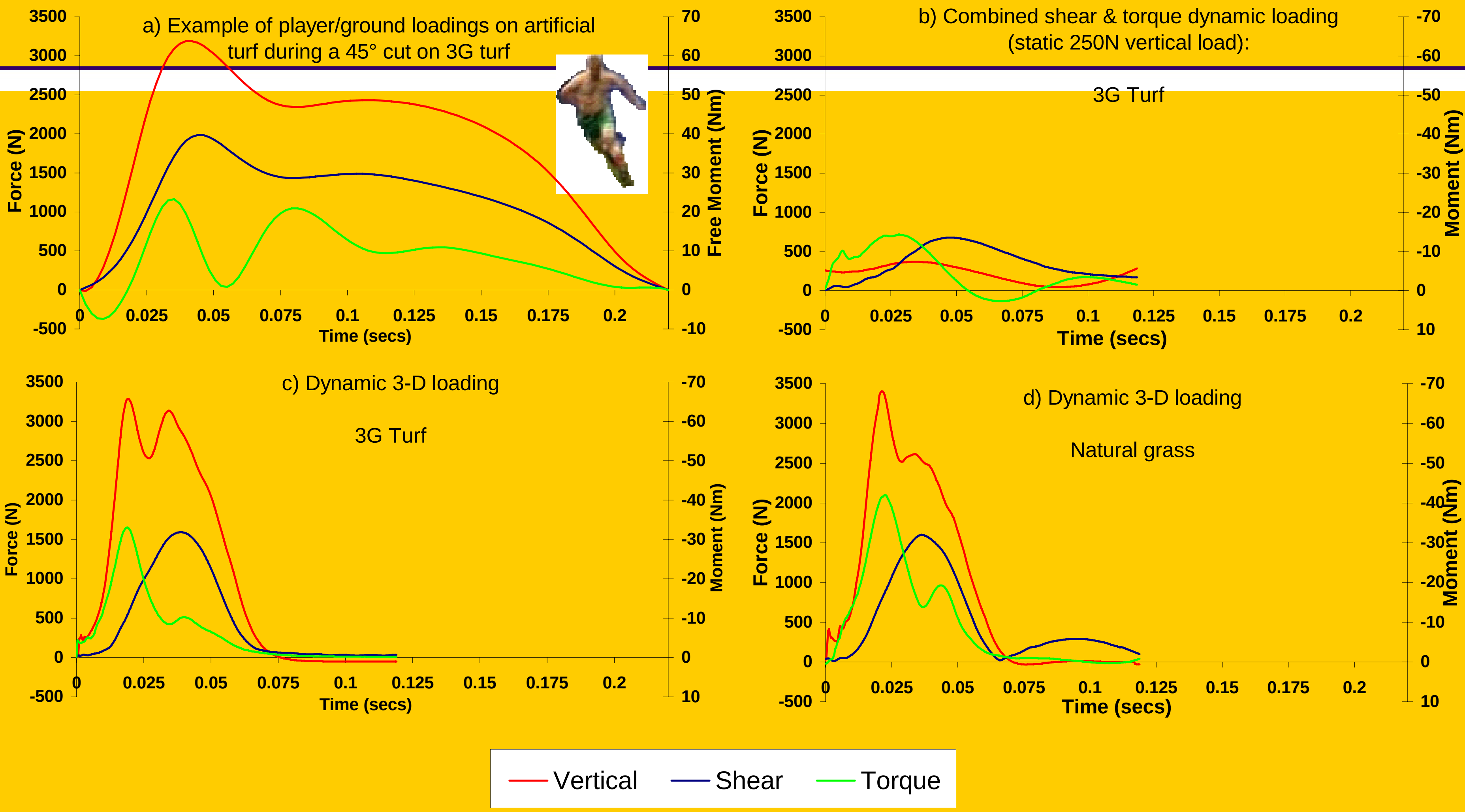
# Pitch Tester (The 'Beast')

**Steve Blackburn, Colin Walker, and Sandy Nicol.**

**Strathclyde**

**University, 2003-2006**

# Ground Loadings – a) Player Study, b) c) and d) from Rig




S Blackburn/ C Walker/ S Nicol, Strathclyde University.

# Some Findings…1 (Traction)

- Rotational Traction Device - not a very sensitive tool?

  Torque expected to vary with thickness of compressible layers and normal force etc….?
- Current Equipment - wrong level of (static) normal force, and load rate….(operator influence)
- Are the torque levels specified correct for Rotational Traction??

Accuracy and precision look low…

# Some Findings…2 (Impact)

- Impact testing – several tools available, selection should be based on purpose (standards, monitoring, research..)
- Good understanding of *material* stiffness, damping and layer interaction effects is required.
- Berlin is a constant energy test, large experience gained hence continuation..?

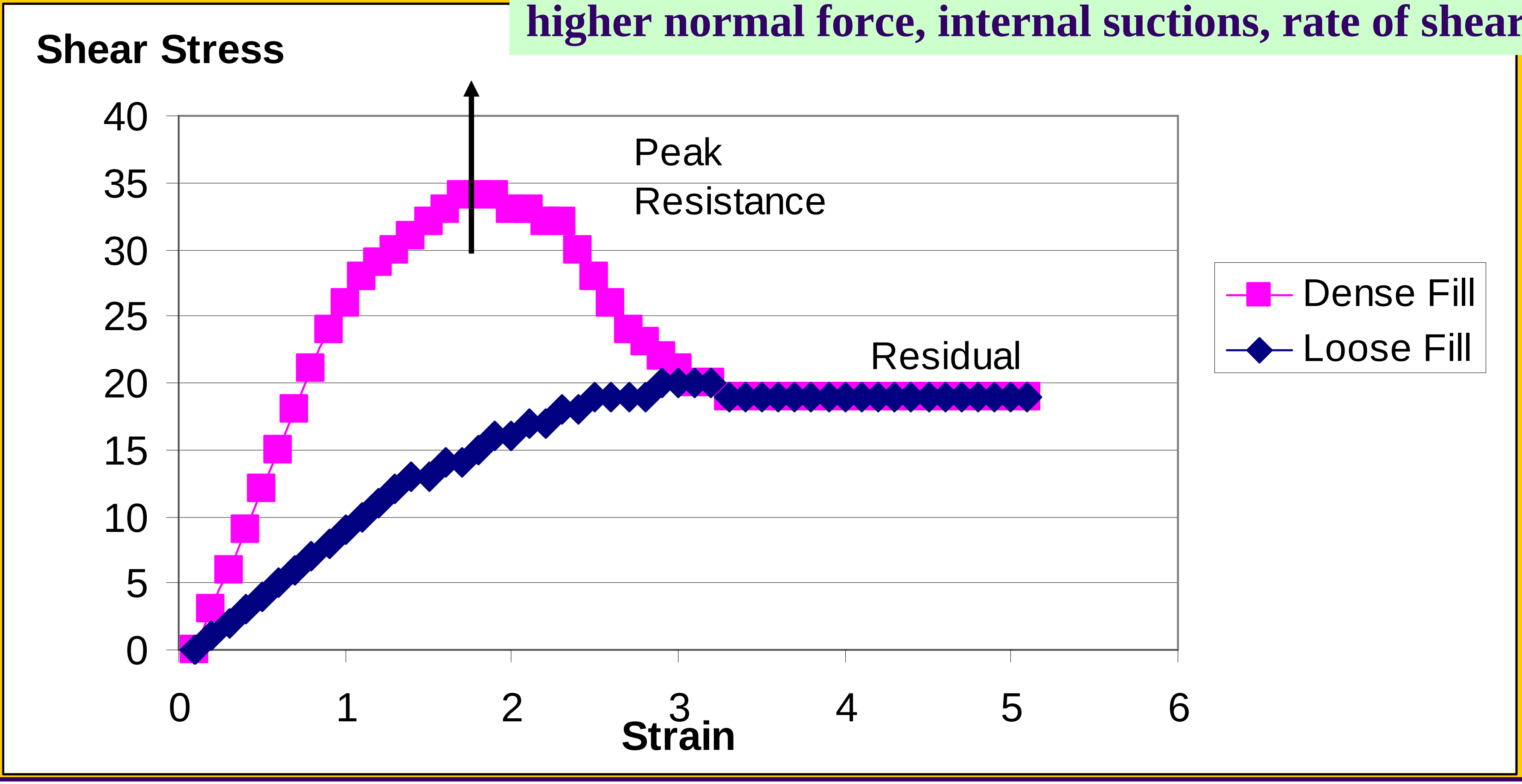
  Controlled force could be more effectively utilised? Fits biomechanical data better…?

# FILL ISSUES

- **Fill material type (recycled rubber, EPDM, sand, water, other…**
- **Fill source – size ranges, shape, method of production**
- **Mechanical properties – test methods for particle packing, friction, compressibility/strength? Temperature effects..**
- **Ease of installation – 'equilibrium' state..?**
- **Long-term behaviour – degradation, fouling, compaction, drainage effect**

# Fill Mechanics - Shear strength (linear)

**Increased peak for higher density/compaction, higher normal force, internal suctions, rate of shear**



# 3G Maintenance – Effects?


**Frosty day – reverse compaction effects?**

# CARPET ISSUES

- **Yarn type**
- **Yarn properties – strength, stiffness, resilience..**
- **Yarn source - size ranges, shape, method of production**
- **Long-term behaviour – degradation through wear, environmental effects**
- **Mechanical properties – test methods?**
- **Temperature effects?**
- **Other – seaming, rucking, colour etc..**

# General Research Required

- **<u>DEVELOP PITCH SCIENCE</u>**
- Classification of surface systems and ‘state’ – way of comparing between data sets
- Accurate/Sensitive Test Methods

  (based on player loadings, material behaviour aspects)
- Thorough investigation of the factors influencing measurement accuracy & sensitivity

MORE HIGH QUALITY PUBLISHED DATA NEEDED !!!

# THANKYOU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